CHAPTER 4 - STONE MASONRY STRUCTURES

SECTION 1. INTRODUCTION

4.1.1 BACKGROUND. Throughout the 19th century, stone masonry was generally used in constructing graving docks, quay walls, and wharves. As late as the 1850s, the cut stones of granite were set in lime mortar; after that, they were set in portland cement mortar.

4.1.2 DESIGN. In most instances the quarried and trimmed building stone used in graving docks is granite (Figure 4-1). These structures usually incorporate massive gravity walls, the stability of which is a function of their mass. The designers of masonry waterfront structures specified greater mass, proportional to the expected loads, than is customary with mass concrete used today. Granite masonry usually develops no maintenance problems except at the joints.

SECTION 2. METHOD OF INSPECTION

4.2.1 VISUAL. The stone blocks in these old waterfront structures have been subjected to weathering, extraordinary loads, abrasion, and seawater. The best visual indication of how well they have resisted weathering is their general appearance. Blocks of high-quality stone retain their sharp edges and corners and their delicate tool marks for many years. After a century of service, these distinguishing attributes may no longer be present.

Empty graving docks should be inspected for leaking groundwater through the joints in their stone floors and sidewalls and for leaking seawater around the seals of the closure to the basin. All joints should be examined for cracks and erosion. The earth behind the sidewalls should be inspected periodically for settlement. Movement of the sidewalls of a graving dock or quaywalls is usually revealed by an increase in width of cracks in adjacent paved areas atop the earth behind the walls. If leaks are detected, note the rate of discharge and whether or not material is suspended in the water. Divers should investigate for scour and undermining, especially outside the closure (Figure 4-2).

4.2.2 SETTLEMENT. If settlement of the structure is suspected, establish points for a level survey; locate these points on both sides of each suspected joint and at both ends of the masonry structure; these points should be related to permanent bench marks established previously by the U.S. Coast and Geodetic Survey. For a graving dock, these points should be located at the tops of the sidewalls, at the floor adjoining the sidewalls, along the longitudinal centerline of the floor, and along the outer rail of the crane track. Note any condition that could reveal settlement.

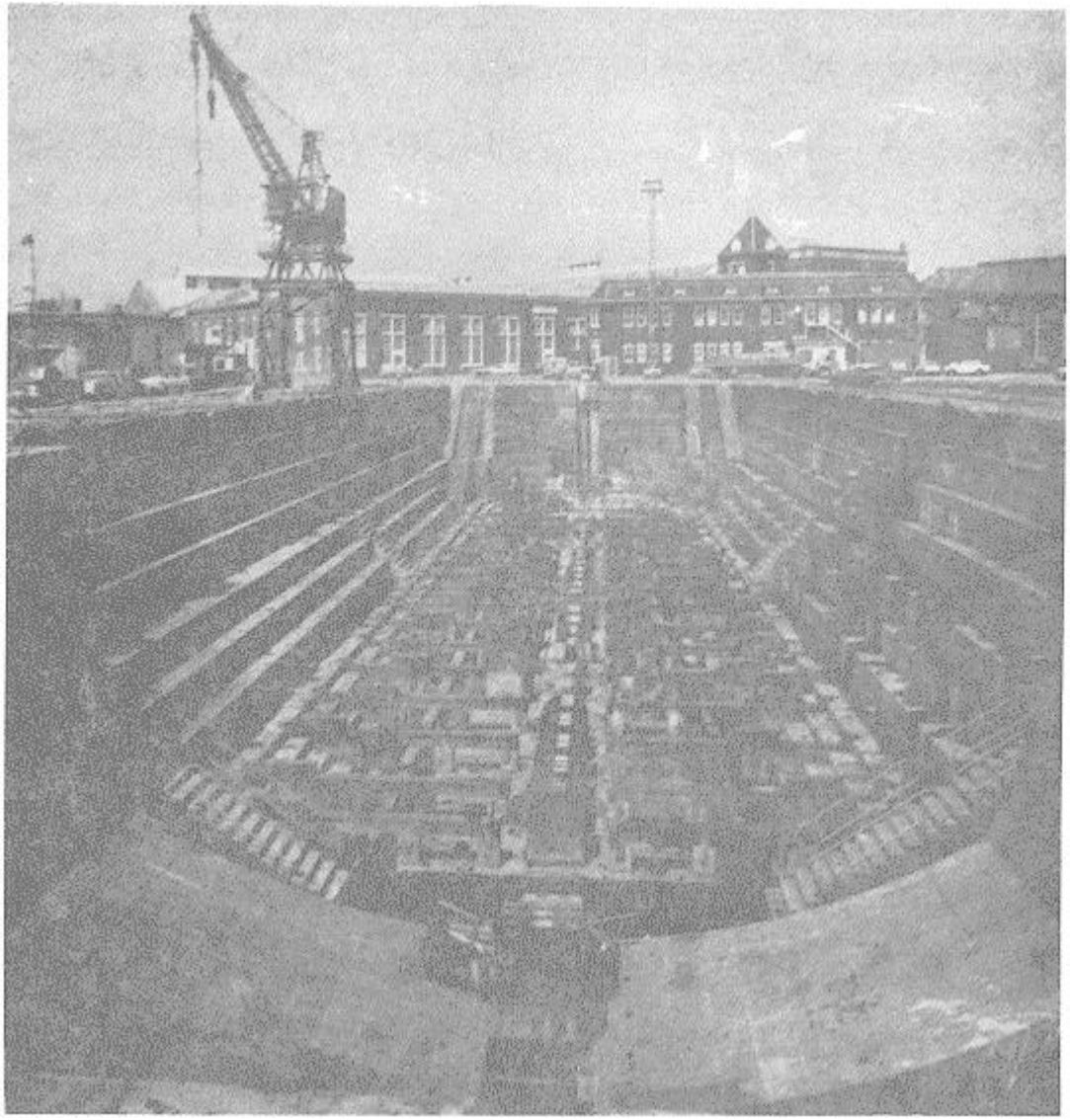

Figure 4-1. Masonry graving dock.

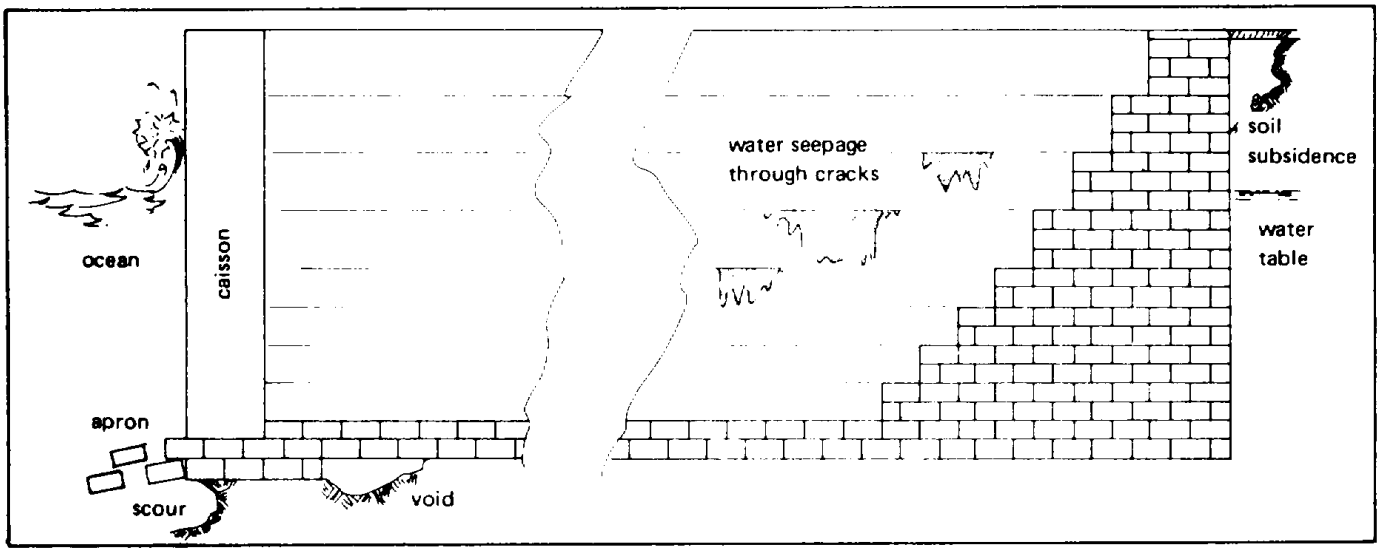

Figure 4-2. Types of deterioration that will require repair.

4.2.3 DOCUMENTATION. Periodically record and/or photograph cracks and related defects to ensure documentation of progressive failure; each photograph should include the data and a scalar guide to enable the viewer to better understand the magnitude of the defect.

SECTION 3. METHODS OF REPAIR

4.3.1 ENGINEERING INVESTIGATION. If a masonry quaywall or graving dock has moved as the result of sliding at the foundation, a structural analysis to determine the cause is necessary before any restoration is attempted. An investigation of the settlement may involve pumping dyed water through cracked or leaky joints to determine the extent of hidden cavities or voids; the existence of a cavity would be confirmed by finding the colored water at some drainage outlet. After such an investigation has yielded the location, depth, and extent of the cavity or void, a program of grouting must be planned.

If any portion of the masonry structure is damaged, or if any stone blocks are loose, repairs should ensure that the bond between the blocks is restored. If a masonry quaywall or sidewall of a graving dock is cracked due to unequal settlement, restoration should be delayed until the cause of settlement has been corrected.

4.3.2 WEEP HOLES. If there is evidence that water is collecting behind the quaywall, and if weep holes are part of the installation, the holes should be cleared to allow drainage. If this procedure is insufficient to relieve the pressure, additional weep holes should be drilled.

4.3.3 SHRINKAGE CRACKS. Shrinkage cracks in joint mortar appear as hairline cracks; they are usually found in vertical joints. If the masonry exhibits signs of leakage, hairline cracking can also be present in the horizontal beds of mortar. Spalled mortar can be caused by many cycles of alternate freezing and thawing.

4.3.4 TUCK-POINTING. Defective joints can usually be repaired by tuck-pointing with portland cement mortar; a skilled stone mason is required. Tuck-pointing only the obviously defective joints does not ensure that the untreated joints will not leak; therefore all joints, vertical and horizontal, in the face of the wall should be tuck-pointed. This procedure requires removing and replacing all mortar to a depth of at least 5/8 inch throughout every joint. Each joint is raked to a depth not greater than 1 inch, unless the old mortar is so defective that removal to a greater depth is necessary. The depth of old mortar removed should be such that sound mortar will serve as the base for the new mortar. All exposed sound mortar must have a clean, square-cut surface. All dust and dirt within the raked joint should be washed out by a jet of water. Wherever old mortar is raked out deeper than 1 inch, the hollow spots must be filled with new mortar first so that a uniform line is created. The cleaned joints are tuck-pointed with the portland cement mortar while the masonry is still damp (not wet) from washing out the raked joints.

The mortar is mixed at least 1 hour before use to ensure prehydration, which stabilizes the plasticity and workability of the mortar and minimizes any tendency to shrink after insertion into the joint opening. A suitable mortar incorporates a special masonry cement (Type II portland cement and a plasticizer), silica sand, and freshwater. It has a somewhat stiff consistency to enable it to be tightly packed into place. The sand/cement ratio should be about 3 to 1 by volume. Placement should be done as follows:

(1) Insert a base layer 3/16 to 1/4 inch thick
(2) Insert the second layer when the base is sufficiently set so that no fingerprint can be made (use a sample representative of the first layer)
(3) Allow the second layer to set for several hours before the joint is finally packed to its full depth and tooled at the face

After tuck-pointing, the masonry should be maintained in a damp (not wet) condition for at least 72 hours. Note: modern epoxy-based materials should be permitted as an alternative to portland cement mortar.

4.3.5 GROUTING. Leaky stone masonry structures can be sealed effectively with less cost by using grout, provided the cement-base stabilizing mixture contains an intrusion aid. The consistency of the intrusion mixture is that of a smooth slurry. This mixture is pumped into holes previously drilled at various intervals to various depths without damaging the integrity of the structure. Before the intrusion grout is pumped, the holes are tested by pumping water to see if the drilling is adequate and to determine the correct consistency for the slurry repairs. Technical details relative to portland cement grouting are given in Reference 4-1.

Details for the use of portland cement grout in reducing leakage by more than 90% in a gravity-type dam of rubble masonry faced with ashlar are described in Reference 4-2. It is shown that (1) isolated grouting tends to hinder the flow of grout injected later through adjacent drill holes, and (2) pumping the grout simultaneously into a multiple series of drill holes ensures good penetration into any fissures within the structure.

The pressurized injection of latex siliconate, a method of grouting developed during the 1960s, has been successfully used in England for making masonry structures watertight [4-3].